DISTRIBUTION OF AFFERENT CONDUCTORS IN THE DIVISIONS OF THE HEART

by

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The problem of the afferent innervation of the heart with *depressor* nerves is now solved in principle. Nevertheless there is a lack of experimental work that may accurately determine the course of the afferent fibers, their distribution as well as the distribution of their endings in the different layers and divisions of the heart.

We tried to solve this problem by experimentation with the hearts of cats and young goats. In ten cases of the investigation described the right *vagus* nerve of the animals was divided. In twenty one case — it was the left *vagus* nerve in the neck of the animal, 1—2 cm lower than g. *nodosum* that was divided.

The time elapsed after operation varied from 19 to 144 hours.

In each heart the following divisions were studied: the right and left *atrium* (the *anterior* and *posterior* walls) the atrial *septum* and the ventricles. The heart was studied on section and total preparations. The material was stained by the BIELSCHOWSKY—GROS method.

Studying the experiment material with *vagus* nerves division we established that both *vagus* nerves participate in the formation of the afferent cardial *plexus*.

The afferent cardial *plexus* is formed by thick myelin fibers (5—8 microns) in which it is easy to distinguish clearly the initial middle and final divisions.

From the analysis of literature data it becomes evident that the investigators which dedicated their work to the study of the afferent innervation of the hearts of men and animals did not give a complete picture of afferent *plexus* structure but described only the third division of the afferent cardial *plexus* with its nerves fibers and afferent endings. This *area* has different names in their work depending on the completeness of their observations. The ending *area* of the afferent *plexus* that has been more or less fully exposed some call the afferent cardial *plexus*. Others call it *receptor* field, and others, who have it less fully observed describe it as separate afferent ending. The initial and middle areas of the cardial afferent *plexus* till now were left not investigated by scientists.

We established that the initial and middle divisions of the afferent *plexus* are situated in the vegetative trunks *plexus* and that the terminal division lies separately.

The afferent fibers of the initial division are located in the big trunks of the subepicardial, myocardial and endocardial heart *plexus*es. These are thick (7,5—8 μ) myelin fibers not branching and not anastomosing with the vegetative fibers running near by.

The afferent fibers of the middle division lie in the middle trunks of the heart *plexus*. In conformance with the course of the nerve trunks of this *plexus* and in the spots of their ramifications the afferent fibers are repeateadly dichotomically divided while their diameter remains unchanged. A part of the fibers formed as the result of division penetrates into the surrounding tissue where it terminates in afferent receptors.

The terminal division in the last division of the afferent *plexus*. Its fibers lie freesly in the innervated layer and terminate in separate afferent endings or in massive *receptor* fields. These are composed of a system of branching and intersecting afferent nerve fibers and of the afferent endings mass. Multiple terminal *receptors* of the afferent *plexus* are compact type endings the terminal twigs of which are in contact with the *nuclei* of the glial cells. The form of the endings is more often tree-like and more rarely clew-like with a series of forms between them (Fig. 1).

Afferent fields were observed in the *epicardium, myocardium* and *endocardium* of the *atriums* as well as in the *epicardium* of the ventricles. In some cases one field was bound to another by the passing of fibers from one *plexus* into another. The *area* occupied by the *receptor* fields reached in some cases 1 cm^2 and the number of endings could be counted by hundreds.

The *receptor* fields are disposed in determined areas of the heart i. e. they penetrate through the thickness of the *vena cava* mouth walls and the *posterior* wall of the right and left *atrium* of ventricles.

Refering to the question of the afferent fibers distribution in the different parts of the heart it is to be noticed that the latter run through the nerves trunks of the vegetative *plexus*.

While dividing the *vagus* nerves and investigating the expansion in the heart of the degenerated afferent fibers passing through each nerve it was found that the afferent fibers of the right and left *vagus* nerves enter the same *areas* of the heart. Thus the right *atrium posterior* and *anterior* walls are innervated with afferent fibers passing through the left *vagus* nerve. Simultaneously afferent fibers are brought into the right *atrium* by the right *vagus* nerve. Here the afferent fibers of both nerves terminate in afferent endings.

Afferent fibers of both nerves form massive *receptor* fields in the right *atrium*. The right *vagus* nerve at the expence of the afferent fibers forms fields predominantly in the *area* of the *vena cava* mouths (Fig. 2) while the afferent fibers of the left *vagus* nerve form fields in the *area* of the *posterior* wall of the *atrium* (see Fig. 1).

The afferent fibers and the endings of the right and left *vagus* nerves are found in the same layers of the right *atrium*. It can be often seen how the *epicardium* (see Fig. 1, 2), the *myocardium* (Fig. 3, 4) and *endocardium* (Fig. 5, 6) of the right *atrium* are innervated with the afferent endings of the right and left *vagus* nerves afferent fibers.

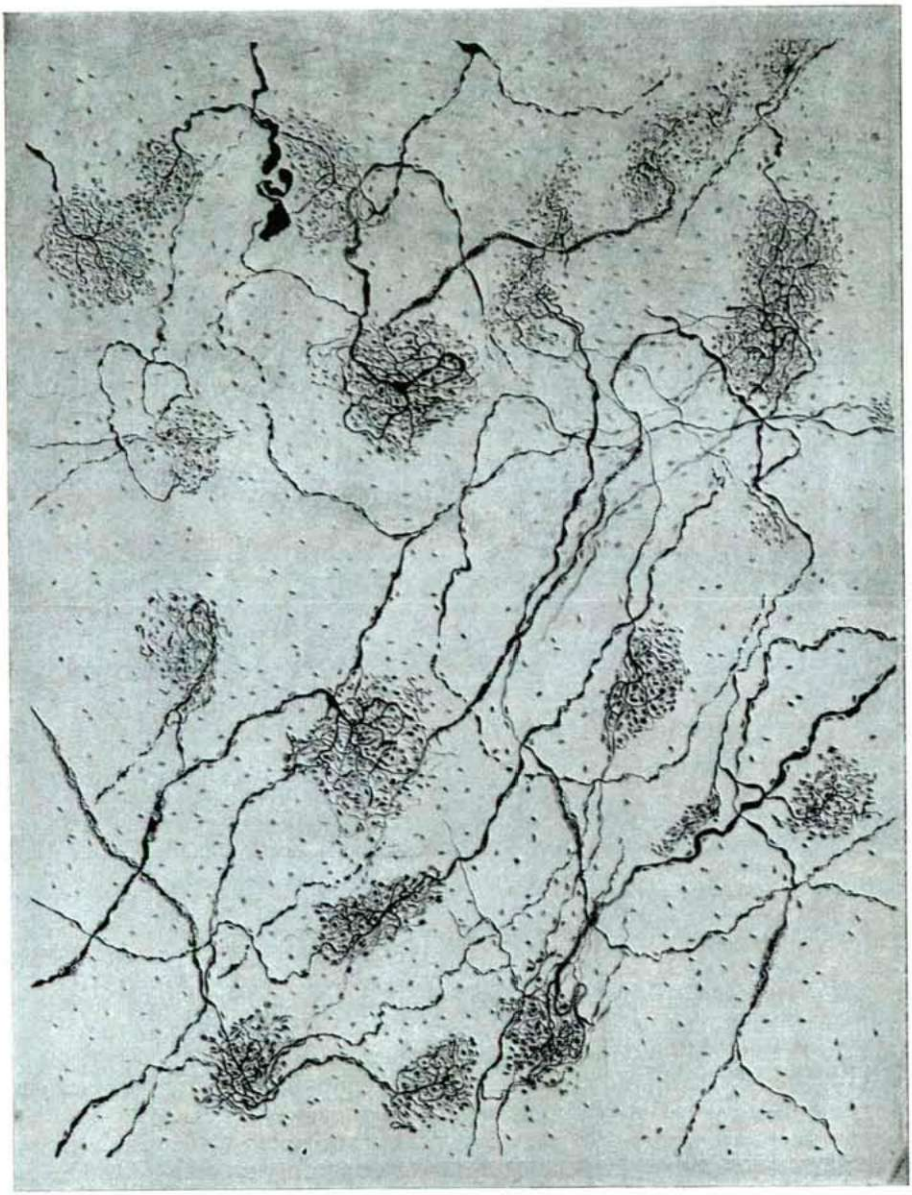

Fig. 1. Afferent endings and the character of their relationship with the fibers of the afferent *plexus* (72 hr after division of the left *vagus* nerve). BIELSCHOWSKY GROS M—9, objective 40, eyepiece 10.

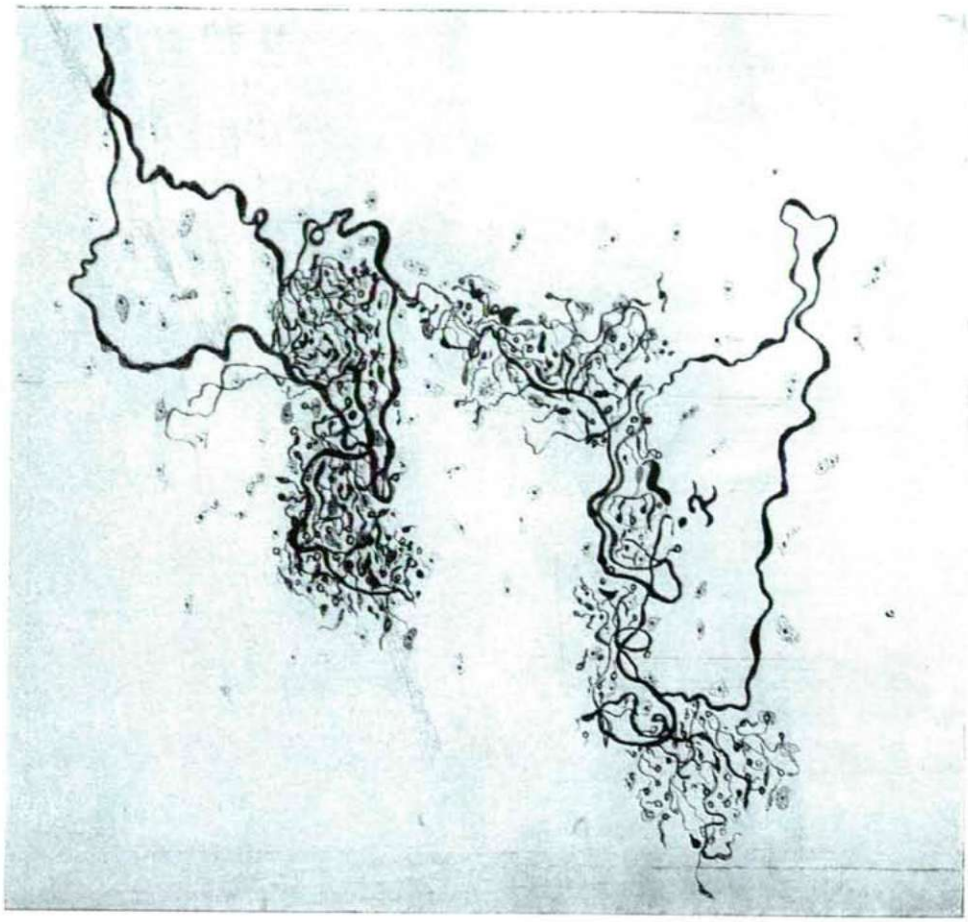

Fig. 2. Terminal division of the afferent *plexus* at the mouth of the *posterior vena cava* of a cat (border between the inner and outer layers) (96 hr after division of the right *vagus* nerve). BIELSCHOWSKY—GROS. MB—1, objective 40, eyepiece 10.

The structure of the afferent fibers of the right and left *vagus* nerves does not differ. The variations taking place in the structure of the afferent apparatuses are determined by the innervated tissue. This is confirmed by the fact that the afferent endings of the same nerve may have a different structure depending upon its location (muscle, connecting tissue).

The same regularity (the part played by both nerves) was noticed by us in the left *atrium* too with the only difference that the *receptor* fields here were met more seldom and they belonged to the afferent fibers of the left *vagus* nerve. Exactly as in the case of the afferent innervation of the right *atrium* we observed in the same layer the afferent endings of both nerves.

Meanwhile it is to be noticed that the left *vagus* nerve innervates predominantly the *myocardium* of both atria and the right, — the both atrial *endocardium*.

In the atrial *septum* afferent endings were found. They belonged only to the afferent fibers passing through the right *vagus* nerve.

The endings and the *receptor* fields found in the ventricles *epicardium* were formed by the afferent fibers of the left *vagus* nerve (Fig. 7).

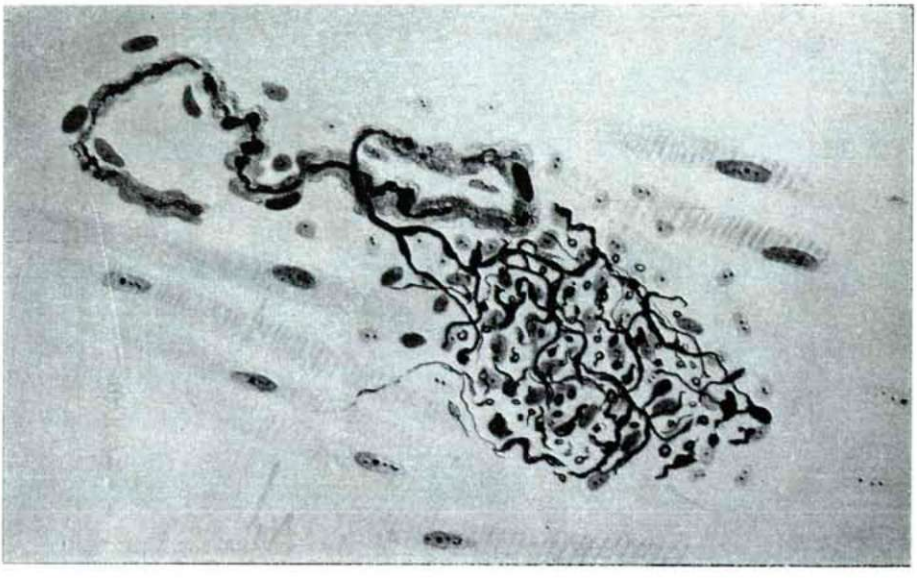

Fig. 3. Degeneration of an afferent ending in the interstitial tissue of the *myocardium* from the *posterior* wall of the right *atrium* of a cat (72 hr after division of the right *vagus* nerve). BIELSCHOWSKY—GROS. KRAUSE—BAUSCH, objective 90, eyepiece 6.

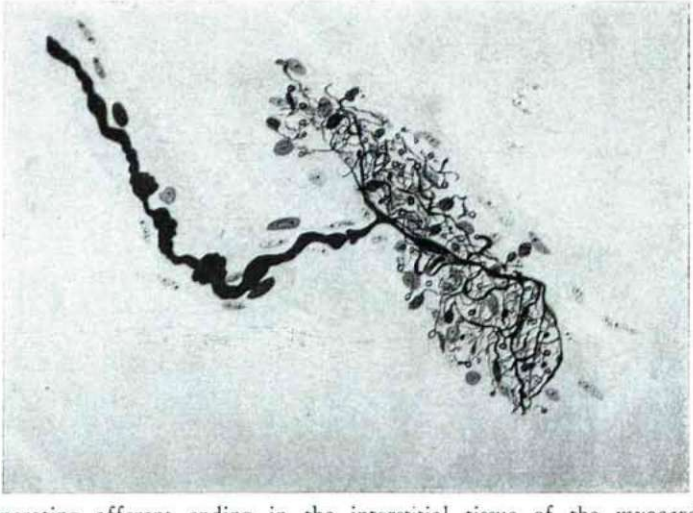

Fig. 4. Degenerating afferent ending in the interstitial tissue of the *myocardium* of the *posterior* wall of the right *atrium* of a cat (72 hr after division of the left *vagus* nerve) BIELSCHOWSKY—GROS. MB—1, objective 40, eyepiece 6.

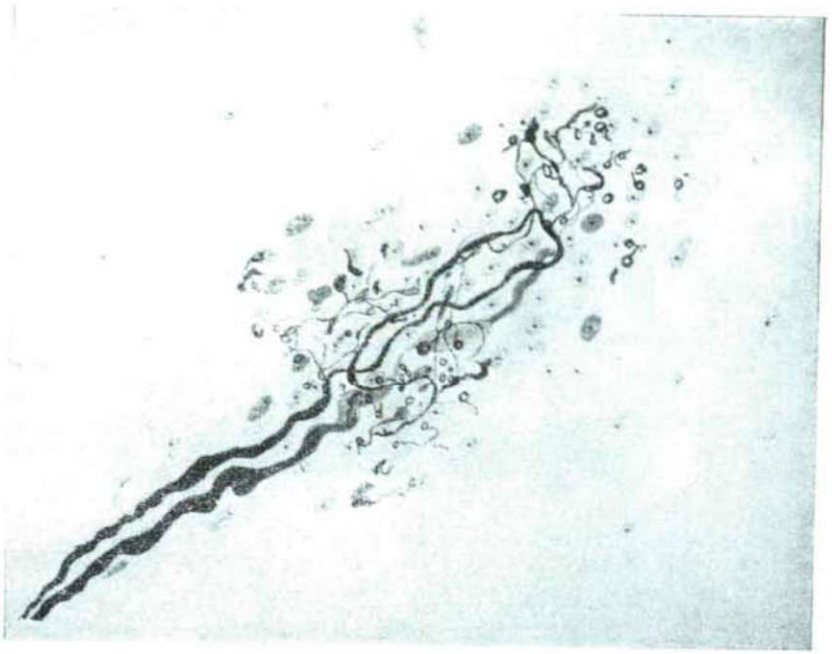

Fig. 5. Degeneration of an afferent ending in the *endocardium* of the *posterior* wall of the right *atrium* of a cat (72 hr after division of the left *vagus* nerve). BIELSCHOWSKY—GROS. MB—1, objective immersion 90, eyepiece 6.

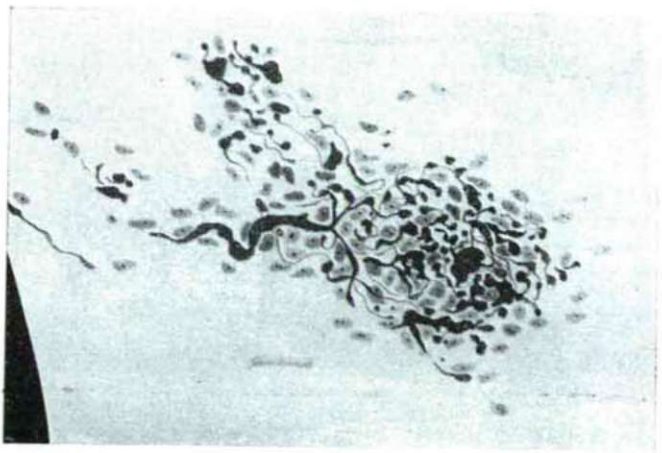

Fig. 6. The final stage of degeneration of afferent endings in the *endocardium* of the *posterior* wall of the right *atrium* of a cat (96 hr after division of the right *vagus* nerve). BIELSCHOWSKY—GROS. MBI—1, objective immersion 90, eyepiece 10; Baush & Lomb, objective 43, eyepiece 10 sic.

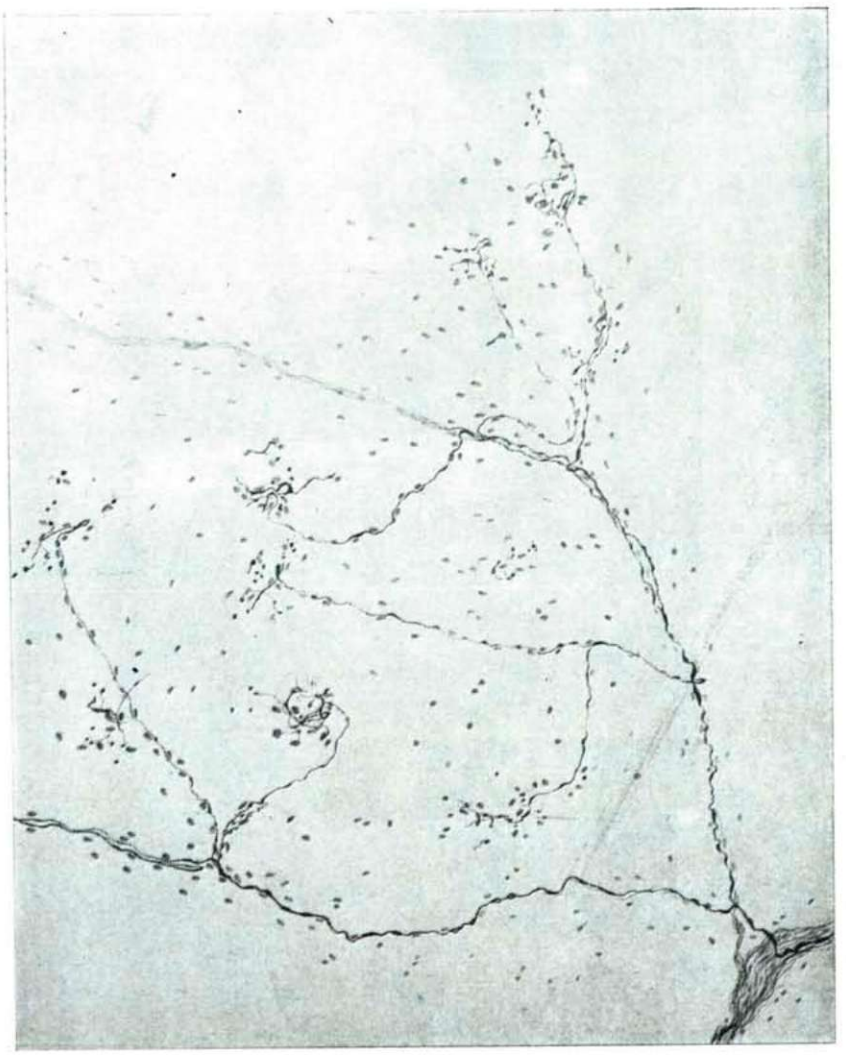

Fig. 7. The terminal division of an afferent *plexus* in the superficial layer of *the epicardium* of the ventricle of a young goat (72 hr after division of the left *vagus* nerve). BIELSCHOWSKY—GROS. MBI—1, objective 40, eyepiece 17 (total preparation).

The above mentioned data show that an intersection of afferent fibers takes place in the heart. A part of the afferent fibers of the right, as well as of the left *vagus* nerves innervate the right *atrium* while their other part innervate the left *atrium*. In this relation our experimental morphological data is in conformance with the indications given in the investigations carried out by I. F. CYON and LUDWIG (1886) upon the course taken by the *depressor* nerves fibers in the heart.

Simultaneously the informations given by *Nettleship* (1936) upon the innervation of the heart are completed with the description of the fully discovered by the author afferent *plexus* from the afferent extracardial nerves up to their endings.

While dividing the *vagus* nerves we obtained an evident degeneration of the afferent nerves and their endins. The presence of all the process stages beginning with the initial up to the terminal show without any doubt that they belong to the afferent fibers running in the *vagus* nerve composition.

Bibliography

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